

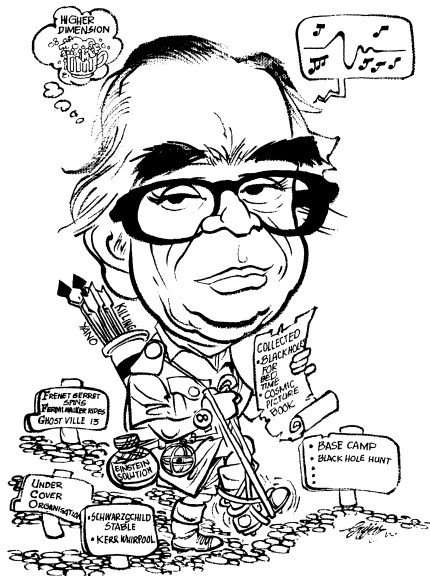
# C.V. Vishveshwara: Beyond the Black Hole Trail

**Bala Iyer**

ICTS-TIFR,  
Bangalore, India

**ICTS, Bangalore, 23 Feb 2017**





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- For the word pictures and the Sydney Harris like cartoons he created to share with his professional colleagues and the lay public the esoteric consequences of Einstein's general theory of relativity.
- His talks inspired generations of students to a career in science and via the activities at the Jawaharlal Nehru Planetarium and Bangalore Association for Science Education the inspiration lives on.



- Born 6 March 1938, Bangalore
- B.Sc., (Hons)(1958) Mysore University, India,
- M.Sc. (1959) Central College, (then) Mysore University, India,
- Columbia University, New York A.M. (1964)
- Ph.D. (1968) Maryland University, MD, USA
- Ph.D. Dissertation: Stability of the Schwarzschild Metric
- Ph.D. Advisor: C.W. Misner
- Institute of space studies (1968-69), Boston Univ (1969-72) , New York Univ (1972-74), Univ of Pittsburgh (1974-76)
- RRI: 1976 - 1992
- IIA: 1992 - 2005
- JNP: 1988 - 2017 (Various capacities)
- Ringdown: Jan 16 2017 Bengaluru
- Vishu is survived by his wife Saraswati and daughters Smitha and Namitha and his three grandchildren

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- 1939: Oppenheimer and Snyder showed that a person who rides through this surface on an imploding star will feel no infinite gravity or see no breakdown of physics there.

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- Idea that intrigues and fascinates the scientists and the lay public even to this day.

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# Issues and questions

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- If the black hole is an object from which no information can escape, how can one look for it?
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- Vishu's seminal research center on these topics and earned him the fond title of *Black Holy man of India!*

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- *Generalization of the "Schwarzschild Surface" to Arbitrary Static and Stationary Metrics*, C. V. Vishveshwara, J Math. Phys., 9, 1319 (1968).
- Regarding this work Jacob Bekenstein commented:  
*I was familiar with the Vishu theorem that the infinite redshift surface of a static black is always the horizon. At that time black hole physics was just getting started and such neat relations between black hole features were rare. Vishu's theorem was a welcome hard fact in the middle of such folklore and helped clarify in mind what black holes were about. At the conference (GR6) I had a long talk with him and I vividly remember being impressed by the range of research problems he had going simultaneously.*

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- *“The surface on which the timelike Killing vector becomes null will itself be a null surface iff the rotation vector of the Killing vector field also becomes null on it. Only under this condition will the infinite red-shift surface act as one way membrane also”*

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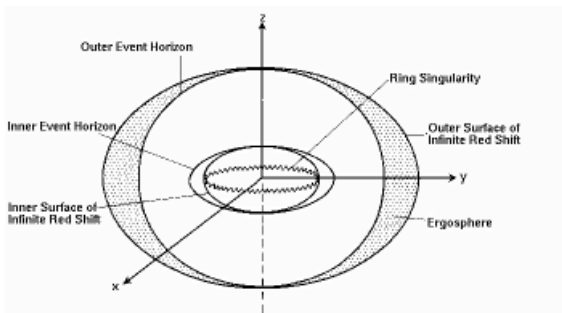


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- The region in between is the ergosphere



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- Talk by Amitabh Virmani

# Quasi-normal modes

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- [Scattering of Gravitational Radiation by a Schwarzschild Black Hole, C. V. Vishveshwara, Nature, 227, 936 \(1970\)](#)
- [Talk by Sathyaprakash](#)

# Vishu's Tale

- Misner proposed the following problem for my Ph.D. thesis. Take these two entities that are now called black holes. Revolving round each other, they come closer as energy is radiated away in the form of gravitational waves. They coalesce into an ellipsoidal 'Schwarzschild surface' still rotating and radiating. Study the whole process, computing all the characteristics of the emitted gravitational radiation. Fine, I said, thy will be done! At the time I did not realize the magnitude of this problem. Had I pursued it, I might have entered the Guinness book of records as the oldest graduate student alive that too without financial support. Anyway, this proposed problem required the understanding of two aspects of black holes: the geometrical structure of a black hole and the perturbations of its spacetime. *Vaidya-Raychaudhuri Lecture*

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- Now for the worst-of-times aspect. Unfortunately, no one seemed to be interested in this kind of research. After all, neither black holes nor gravitational radiation had been detected, but only theoretically predicted. Why should anyone spend time investigating the interaction between two unobserved entities, perhaps of doubtful existence? *Schucking Fest*

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- It was a magical experience; an exotic cocktail of science, art, humour and caricature. Equations were not necessarily abstract and unspeakable and could well be translated in the best literary tradition if you were Vishu!



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- Perturbations of black holes in general relativity carry signatures of the effective potential around them and one could look for them by examining neutrinos in gravitational collapse or existence of ultracompact objects.

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- How different are black hole solutions in cosmological backgrounds from those in the usual asymptotically flat ones.

## Analytical Theory of Optical Black Hole Analogues Suraj S. Hegde, C. V. Vishveshwara, arXiv:1209.5148

We develop an analytical formalism for studying optical analogues of spherically symmetric black-hole spacetimes. ... Manifest properties of black holes like curved light trajectories follow directly from our formalism. Other black-hole phenomena like quasinormal modes can also be studied within this framework. .... These optical black holes can be employed to investigate black-hole phenomena with table-top experiments.

- Black Holes: Characterization, Stability, Quasi normal modes, Physical effects, EM fields around them
- Exact Solutions and trajectories in them
- Perturbations in GR (Hertz potential, Dirac equation)
- Signatures of Effective potential in physical effects
  - Neutrinos in strong gravitational fields
  - Neutron stars, Ultra-compact objects in GR
- Black Holes in Higher dimensional ST, Higher derivative theories (Lovelock)
- Frenet-Serret approach to Gyroscopic precession, Inertial forces in GR
- Black holes in Cosmological ST
- Killing Tensor and its possible physical interpretation

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- Together with A. Ratnakar, Vishu was instrumental in setting up the RRI Film Club in the 1980s to get access to movie classics from National Film Archives in Pune and from the consulates like the German and French ones.

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- A volume entitled Random walk in relativity and cosmology co-edited by them was released in 1986 at RRI and the royalties from its sales supplemented by royalties of the ICGC proceedings used to set up the Vaidya-Raychaudhuri Endowment Lecture of the IAGRG.

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# GR Community Building

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- Creating an opportunity for the Indian Association for General Relativity and Gravitation (IAGRAG) community to interact with international experts on front line research areas in relativity and cosmology in India was needed to assist in improving the quality and relevance of general relativity research in India.

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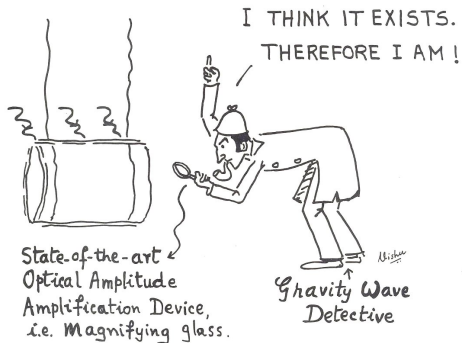
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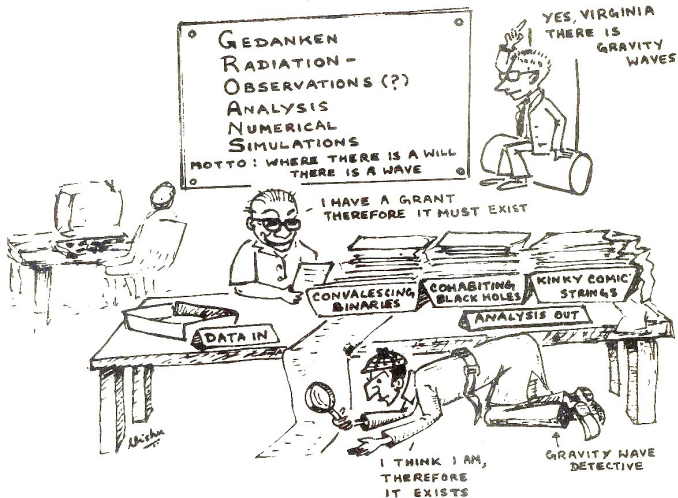
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- Alas they are incomplete since he could not make one after the discovery.

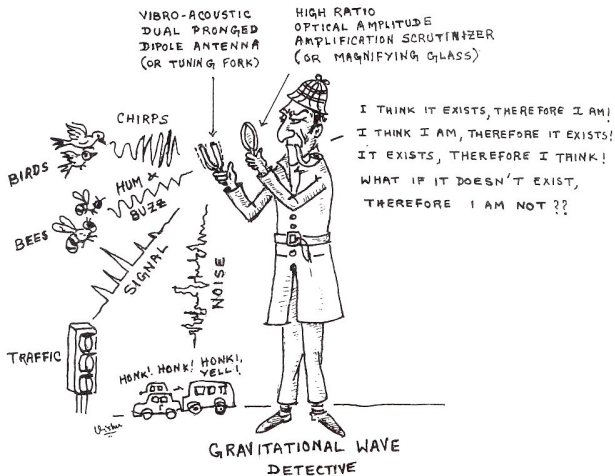


# GRAVITY WAVES



# GRAVITATIONAL RADIATION





Historical Note: The first two of the Cartesian comments above were made earlier by the gravitational wave detective during ICGC-1987, Goa, and ICGC-1991, Ahmedabad, respectively. He has returned with more of his existential expressions.

# The cartoonist inspires

- Just on the day he passed away Nils Andersson wrote Vishu an email:  
*I have recently done something that I think might amuse you. I have written a little book involving Einstein, relativity and a fair bit of fictional freedom. Now, I think it is fair to say that my attitude to this project has been heavily inspired by your story-telling, your drawings and the bathtub book.*

A Gentle Wizard,  
Written by Nils Andersson,  
illustrated by Oliver Dean

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- *This is devastating. I have lost a teacher, a mentor and a friend. More than anything else we are going to miss his 'serious' sense of humour in all walks of life, especially science.*

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- To find means of sustaining it financially he co-edited with Sanjay Biswas and D.C.V Mallik an interesting volume called *Cosmic Perspectives* that was dedicated to the memory of M. Vainu Bappu.

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- **Talks by Shylaja, Vijay in afternoon**



# Bubble Bath Books

- *Einstein's Enigma or Black Holes in My Bubble Bath*, C.V. Vishveshwara, Springer-Verlag, Berlin-Heidelberg (2006).

The Bathtub, The Stellar Bed, The Casanova connection, Footprints of the giants, Cosmic framework, A moving experience, The fabric of ST, Grappling with gravity, Beetles on a branch, TubTalk, The first solution and last statement, Sphere of darkness, The voracious whirlpool, Dynamics of the Unique, A date with Dante, Imprints of the invisible, Celestial swan song, Cibo per la mente, Curtain call, Foundation of fact and fantasy

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- *Universe Unveiled: The Cosmos in My Bubble Bath*, Springer-Verlag, Berlin-Heidelberg (2014).

Reconnecting, Ancient Times, The Founders and the Foundations, Casanova Calls, The Canon and His Cosmos, Hven and the Heavens, The Starry Messenger, The Fall and the Firmament, Lives of the Stars, The First Rung of the Cosmic Ladder, The Map of the Milky Way, Through the Glass Brightly, The Universe: Expanse and Expansion, Space, Time and Gravitation, The Curved Cosmos, The Cosmic Yin and Yang, Food for the Future, Far Horizons

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- The observed profile has very uncanny resemblance with what Vishu had plotted long back in 1970. There are very few predictions which are actually verified by experiment and observation. Vishu's black hole ringdown is one among those few. This is the true and ultimate measure of a seminal insight.

- Many facets of research have emerged since then from the seminal papers of Vishu.. See e.g. The Vishu Fest

*Black Holes, Gravitational Waves and the Universe,  
Essays in honor of C.V. Vishveshwara,  
Eds. B. R. Iyer and B. Bhawal, Kluwer, (1999).*



# Our World Lines will not cross again..

- We will miss you Vishu even as we try very hard to follow your favorite lines from Antonio Machado:

*Traveller there is no Path,  
Paths are made by Walking ..*

